

Development of a telescope for medium-energy gamma-ray astronomy

Since the launch of AGILE and FERMI, the scientific progress in high-energy ($> \sim 200$ MeV) gamma-ray science has been dramatic. However, neither instrument is optimized for observations below ~ 200 MeV where many astrophysical objects exhibit unique, transitory behavior, such as spectral breaks, bursts, and flares.

The Advanced Energetic Pair Telescope (AdEPT) is being developed as a future NASA MIDEX mission to exploring the medium-energy (5–200 MeV) energy range. The enabling technology for AdEPT is the GSFC Three-Dimensional Track Imager (3-DTI) gaseous time projection chamber. The high spatial resolution 3-D electron tracking of 3-DTI enables AdEPT to achieve high angular resolution gamma-ray imaging via pair production and triplet production (pair production on electrons) limited by the interaction kinematics rather than Coulomb scattering. Further, the reduction of Coulomb scattering, allows AdEPT to be the first medium-energy gamma-ray telescope to have high gamma-ray polarization sensitivity.

We describe the instrument requirements needed for the AdEPT mission, the development of the 3-DTI technology, and the performance of a $30 \times 30 \times 30$ cm³ prototype of the AdEPT telescope.

Brief Summary of Paper

Since the launch of AGILE and FERMI, the scientific progress in high-energy ($E_\gamma > \sim 200$ MeV) gamma-ray science has been, and will continue to be dramatic. Both of these telescopes cover a broad energy range from ~ 20 MeV to > 10 GeV. However, neither instrument is optimized for observations below ~ 200 MeV where many astrophysical objects exhibit unique, transitory behavior, such as spectral breaks, bursts, and flares. Hence, while significant progress from current observations is expected, there will nonetheless remain a significant sensitivity gap in the medium-energy (~ 0.1 –200 MeV) regime; the lower end of this range remains largely unexplored whereas the upper end will allow comparison with FERMI data.

Tapping into this unexplored regime requires significant improvements in sensitivity. A major emphasis of modern detector development, with the goal of providing significant improvements in sensitivity in the medium-energy regime, focuses on high-resolution electron tracking. The Three-Dimensional Track Imager (3-DTI) technology being developed at GSFC provides high resolution tracking of the electron-positron pair from gamma-ray interactions from 5 to 200 MeV. The 3-DTI consists of a time projection chamber (TPC) and 2-D cross-strip microwell detector (MWD). The low-density and homogeneous design of the 3-DTI, offers unprecedented sensitivity by providing angular resolution near the kinematic limit. Electron tracking also enables measurement of gamma-ray polarization, a new tool to study astrophysical phenomenon. We describe the design, fabrication, and performance of a $30 \times 30 \times 30$ cm³ 3-DTI detector prototype of a medium-energy gamma-ray telescope.